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March 24, 1992

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5/8/92*

Dr. Donald Liebenberg
Physics Division - Code 4112
Office of Naval Research
800 N. Quincy Street
Arlington, Virginia 22217

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MAY 13 1992
S C D

Dear Don:

Please find included three copies of the Annual Report for my Grant N00014-91J-1438, entitled "Disorder and Transport in Highly Correlated Systems", for the period from April 1, 1991 through March 31, 1992.

My students, postdocs and I would like to thank you and the Office of Naval Research for your support.

Sincerely,

Ivan Schuller

Ivan K. Schuller

IKS:sh
Enclosures

DISTRIBUTION STATEMENT A

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ONR GRANT N00014-91J-1438

"Disorder and Transport in Highly Correlated Systems"

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La Jolla, CA 92093-0319

Annual Report 4/1/91-3/31/92

Statement A per telecon
Dr. Donald Liebenberg ONR/Code 1112
Arlington, VA 22217-5000

NWW 5/11/92

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Introduction

This grant was a new start dedicated to studies of disorder and transport in highly correlated electron systems, mostly superconductors. These studies are most conveniently accomplished in thin film structures. Thin films useful in these type of studies present a number of structural and chemical defects at length scales comparable to interatomic spacing. This disorder may have strong effects on the physical properties and so quantitative structural and chemical characterization is a must.

The developments in the past year have been beyond expectations. We have developed all the growth and structural characterization techniques useful for the preparation of high and low temperature superconducting films and superlattices. These have been applied to the growth and characterization of films which were used in a number of physical property studies. One particularly interesting highlight was the study of the enhancement of superconductivity by light illumination.

II Uniaxial Pressure Dependence of High T_c Oxides

The uniaxial pressure dependence of the superconducting properties of ceramics is an important problem which should yield information on the anisotropic coupling of structure and superconductivity. However, these experiments are complicated by the thin plate shape and extreme fragility of available high T_c crystals. The measurement of the uniaxial pressure dependence of superconductivity in high T_c oxides has been very limited. We developed an alternative method to study this problem. By investigating the hydrostatic pressure dependence of highly-crystalline, oriented thin films on substrates we are able to extract the anisotropic properties of the material.

For instance, figure 1 shows the hydrostatic pressure of a, b, and c oriented $\text{GdBa}_2\text{Cu}_3\text{O}_7$ films on SrTiO_3 substrates. The most striking result is the anisotropic pressure dependence of T_c in the a-b plane, which is quite unexpected.

An analysis of this type of data allows us to extract the uniaxial pressure dependence of $\text{GdBa}_2\text{Cu}_3\text{O}_{7-\delta}$. The study of the pressure induced changes in the

superconducting properties of $\text{YbBa}_2\text{Cu}_3\text{O}_{7-\delta}$, $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$, $\text{DyBa}_2\text{Cu}_3\text{O}_{7-\delta}$ and $\text{GdBa}_2\text{Cu}_3\text{O}_{7-\delta}$ on a variety of substrates implies that T_c has a nonmonotonic dependence on pressure.

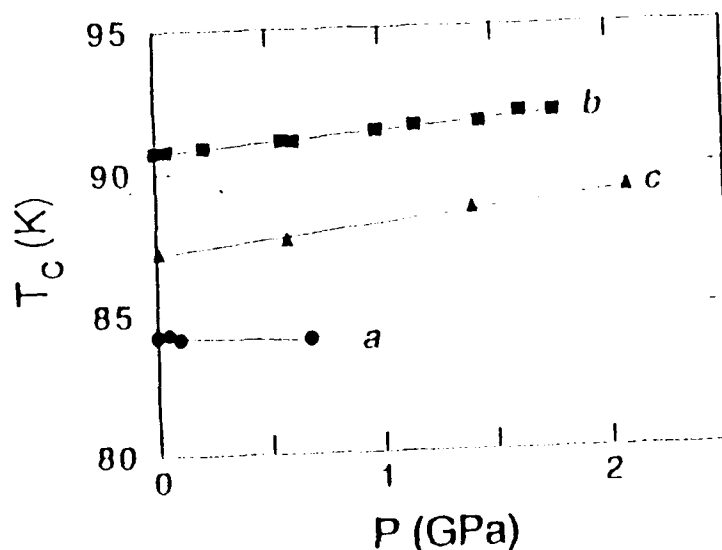


Figure 1 Hydrostatic pressure, P , dependence of the superconducting critical temperature, T_c , for $\text{GdBa}_2\text{Cu}_3\text{O}_{7-\delta}$ films grown on STO. Letters indicate the crystalline axis normal to the substrate.

II. Photoexcitation

The interaction of superconductivity with lasers has been studied extensively in conventional superconductors. The effect for these materials consists in a decrease of all superconducting properties. It has been shown recently that photoexcitation of $\text{YBa}_2\text{Cu}_3\text{O}_x$ (YBCO) reduces the resistivity of the material and that prolonged irradiation leads to a seemingly complete loss of resistivity below 5K.

We have performed a series of detailed experiments to investigate further these effects in thin films of well defined and controlled oxygen stoichiometry.

Figure 2 shows the changes in the electrical resistivity as a function of

temperature, T , before and after laser illumination of a YBCO film with a $T_C \sim 25K$. The normal state resistivity of the film decreases and the transition temperature increases in a clear fashion. In order to investigate the origin of the photoconductivity effect we have performed a series of detailed studies of the resistivity (ρ_{xx}) and Hall resistance (R_H) in oxygen deficient samples. Figure 3 shows the time evolution of ρ_{xx} and R_H during and after illumination by halogen white light. During the excitation both quantities show a decrease as a function of time. A plot of the Hall mobility $\mu = C |R_H|/\rho_{xx}$ shown in Fig. 3c, indicates that the decrease in ρ_{xx} is not simply related to the corresponding decrease in R_H . This implies that the hole mobility also changes with photoexcitation.

The origin of the photoexcitation effect is not understood at the present time and is under investigation.

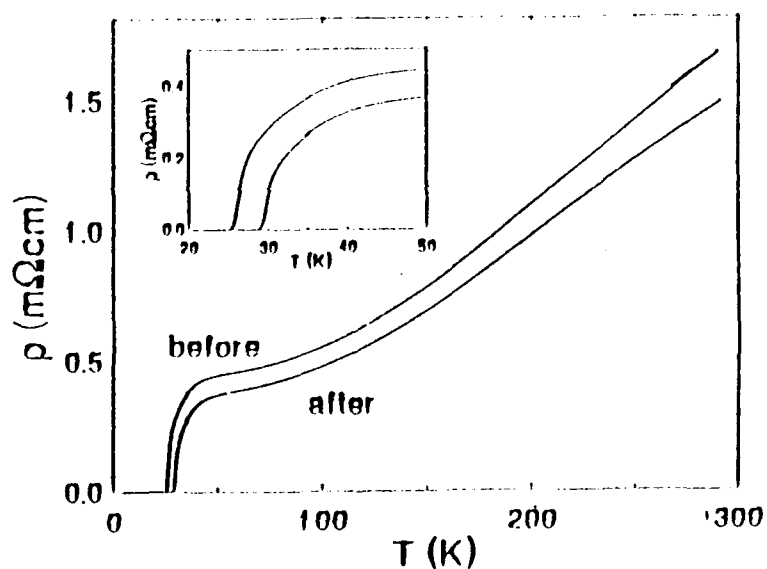


Figure 2. Electrical resistivity as a function of temperature, T , before and immediately after laser illumination for the $T_C = 25K$ film. The Inset shows the region near T_C in an expanded scale.

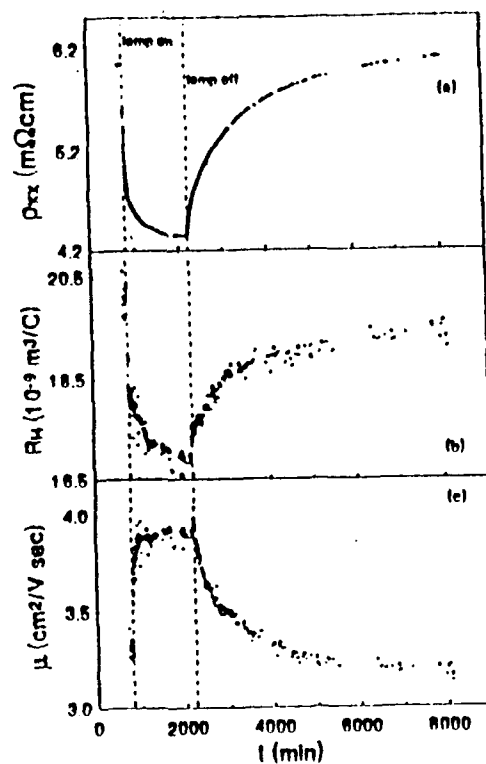


Figure 3. Time dependence at room temperature after Ar ion laser light illumination at 77K of the Hall mobility, $\mu = c |R_H|/\rho_{xx}$ for films of different oxygen content x . Values have been normalized to the initial value, which for all samples is $4.2 \pm 3 \text{ cm}^2/\text{V sec}$.

IV. Publications Under Previous Period Papers

1. **Uniaxial Pressure Dependence of the Superconducting Critical Temperature in $R\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ High- T_c Oxides**

S.L. Bud'ko, J. Guimpel, O. Nakamura, M.B. Maple and Ivan K. Schuller
Phys. Rev. (submitted).

2. **Photoinduced Enhancement of Superconductivity**

G. Nieva, E. Osquiguil, J. Guimpel, M. Maenhoudt, B. Wuyts, Y. Bruynseraede, M.B. Maple and Ivan K. Schuller
Appl. Phys. Lett. (In press).

3. **PhotoInduced Changes in the Transport Properties of Oxygen Deficient $\text{YBa}_2\text{Cu}_3\text{O}_x$**

G. Nieva, E. Osquiguil, J. Guimpel, M. Maenhoudt, B. Wuyts, Y. Bruynseraede, M.B. Maple and Ivan K. Schuller
Phys. Rev. Lett. (Submitted)

Contributed Talks

1. **Uniaxial Pressure Dependence of T_c on $R\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$**

O. Nakamura, S.L. Bud'ko, J. Guimpel, M.B. Maple and Ivan K. Schuller
March 1992 Meeting of The American Physical Society
Indianapolis, Indiana
March 16-20, 1992.

2. **Interdiffusion and Roughness in $R\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ Superlattices**

J. Guimpel, Eric E. Fullerton, O. Nakamura and Ivan K. Schuller
March 1992 Meeting of The American Physical Society
Indianapolis, Indiana
March 16-20, 1992.

3. **Superconducting and Normal State Properties of $\text{Y}_{1-x}\text{M}_x\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ ($\text{M} = \text{Ce}, \text{Pr}, \text{Tb}, \text{Th}$) Films**

G. Nieva, C.L. Seaman, R.F. Jardim, M.B. Maple, J. Guimpel, Ivan K. Schuller, C.R. Fincher and G.B. Blanchet
March 1992 Meeting of The American Physical Society
Indianapolis, Indiana
March 16-20, 1992.

V. Personnel

This grant has provided partial support for two postdoctoral fellows, G. Nieva and J. Guimpel.